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AIR POLLUTION FROM LOCAL HEATING

Goran Person, et al

Environmental Protection Agency
Research Triangle Park, North Carolina

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AIR POLLUTION FROM LOCAL HEATING

Foreword

The National Environmental Protection Service has instituted research into how heating is set up in densely populated towns in Sweden, having more than 15,000 inhabitants, against the background of the great significance of local heating in air pollution situations.

The investigation concerned itself with the following heating methods: oil burning, electric heat or heating with solid fuels, and distribution of heavy and light oils. In addition, communities were requested to provide information about plans concerning remote heating and monitoring to reduce the air pollution situation with respect to sulfur dioxide and soot.

The National Environmental Protection Service, by this investigation which was handled by county government sections of the Service with the help of local authorities, has obtained valuable basic material for future work concerned with the reduction of air pollution caused by local heating.

Bureau Chief Göran Person and Bureau Engineer Bengt Westergård have jointly undertaken this report. Docent

Ulf Högström, Uppsala University, contributed the chapter on meteorological aspects of stack gas discharge.

Solna, January 1, 1969

National Environmental Protection Service

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Introduction

As the result of the current study on air pollution, the National Environmental Protection Service has mapped out how local heating is set up in major, densely populated areas. The environmental protection service section of each county government compiled the data for each county.

The investigation took into consideration all communities of over 15,000 population. The 1964 community classification was used for the purpose (see Appendix 1).

The charting included a schematic account comprising oil, electric and gas heating, together with the spread of eventual remote heating. Remote heating is understood to mean heating from communal heating plants.

The results were obtained from soot and sulfur dioxide measurements in those densely populated communities where air pollution research was carried out.

Energy requirements and fuels for local heating 1955-85

Local heating methods have changed radically since the Second World War. Coal, coke, briquettes and local fuels have, for the most part, been replaced by heating oil. In the decade 1955-1965 the total energy requirement for local heating rose from 52.7 10^9 Mcal/year, i.e. an increase of 65%, while the use of heating oil in the same period

rose from 22.0 10^9Mcal/year to 74.4 10^9Mcal/year, an increase of 338%.

Table 1 shows consumption of the different types of fuels.

Table 1. Use of various types of fuel for local heating for the year 1967 [1].

Type of fuel	Energy supply, in 10^9Mcal				
	1955	1960	1963	1964	1965
Heating oil 1	16.2	26.0	35.7	39.6	43.4
Heating oils 3-5	5.8	14.8	23.5	27.5	31.0
Heating kerosene	0.5	1.2	1.9	1.9	2.1
Coal	4.9	1.3	0.9	0.8	1.7
Coke	13.4	7.0	5.7	4.4	3.5
Briquettes	0.9	0.1	0.1	0,1	0.1
Local	11.2	9.8	7.8	6.5	6.5
Total	52.9	60.2	75.6	80.7	88.2

Calculated in cubic meters this means that in 1965, 5.1 million cubic meters heating oil No. 1 and 3.3 million cubic meters heating oils Nos. 3-5 were used for heating. Coal and coke consumption for the decade 1955-1965 decreased to 20 and 15% of the 1955 value, respectively. The rapid structural change is seen in the table below, which lists the percentage of the various types of fuel relative to total consumption.

[1] Report on Sweden's energy supply, 1955-1985. Energy Committee, Finance Department 1967.

Table 2. Percentage of fuel types of total fuel consumption for local heating [1]

Type of fuel	Percentage of total fuel consumption, %	
	1955	1965
Heating oil 1	30.7	49.2
Heating oils 3-5	11.1	35.2
Heating kerosene	0.9	2.4
Coal	9.2	1.9
Coke	25.4	3.9
Briquettes	1.7	--
Local	21.0	7.4

In accordance with a prognosis by the Energy Committee of the Finance Department a continued decrease in solid fuel is projected, but at a reduced pace, and continued increase in heating with oils and by electricity is expected.

The prognosis gives two alternatives for oil and electricity consumption depending in part on the uncertainty in the total heating requirements for local heating and in part on the uncertainty of electricity's future capability to compete with oil. The Energy Committee has therefore set forth probable maximums and minimums in amounts, as is seen in Table 3. Both alternatives expect a considerable increase in electric heating in the eighties, when several nuclear power plants will be in operation.

[1] Report on Sweden's energy supply, 1955-1985. Energy Committee, Finance Department 1967.

Table 3. Use of oil and electricity for heating in 1965, and forecast for 1975 and 1985 [1]

Type of fuel	Use, in 10^9 Mcal/year				
	1965	1975 alt. 1 High elec. consumption	1975 alt. 2 Low elec. consumption	1985 alt. 1 High elec. consumption	1985 alt. 2 Low elec. consumption
Heating oil No. 1	43.4	66	77	130	160
Heating oils Nos. 3-5	31.0	52	52		
Electricity	0.5	8.6	5.5	22	12

In 1965 the percentage of total energy production used for heating was 34%. The prognosis for 1975 ranges around 40%.

Local heating system in major, densely populated localities

According to the 1964 community classification list, there are 79 densely populated municipalities in Sweden with inhabitants numbering 15,000 or more. Seventy-five of these, all cities, have submitted reports, which provides us with a good picture of the present and future heating systems.

Heavy oil consumption per capita (Table 4) presents no marked difference between various large cities or cities in north or south Sweden, not taking different degrees of centralized heating into consideration.

[1] Report on Sweden's energy supply, 1955-1985. Energy Committee, Finance Department 1967.

Table 4. Use of heavy oils in cubic meters for local heating in 1967, unless noted otherwise

Location	Use of heat. oils 3-5, in m³	Pop. 1 Jan 1967	Use per person
Avesta	17 000	29 400	0,58[1]
Boden	15 000	16 500	0,91
Fagersta	13 000	16 600	0,81
Gällivare-Malmberget	18 000	19 400	0,93
Göteborg[2]	88 800	76 000	1,17[2 3]
Kiruna	22 000	23 700	0,93
Köping	10 000	20 700	0,48[1]
Lidköping	17 700	19 400	0,91
Linköping	79 000	77 400	1,02[3]
Luleå	28 000	39 800	0,70
Lund	56 100	49 600	1,13[3]
Mjölby	13 000	12 600	1,03[4]
Norrköping	85 000	94 000	0,90[2 6]
Piteå	20 000	21 000	0,95[5]
Stockholm	888 900	777 000	1,14
Södertälje	48 000	60 600	0,80
Umeå	40 000	50 700	0,79[3]

(1) Use valid only for residential heating.

(2) Figures valid for the 17 central city sections.

(3) Includes remote heating plant use.

(4) Mjolby has no detailed research figures, but fuel consumption figures submitted to SNV in other years.

(5) Consumption calculated, in part, by the National Environmental Protection Service (SNV).

(6) Exclusive of the heating of the cellulose industry.

A detailed account of how local heating was set up in the various localities was of general interest. The material was assembled by the Air Control Bureau of the SNV and by county by the Environmental Protection sections of the county governments and will be used as the basis for future measures aiming at reducing air pollution caused by local heating.

At present there are remote-heating facilities in 18 cities and communities and among those are the ten major cities of Sweden (Table 5). Heating requirements made on remote-heating plants vary widely with respect to residential heating, from 98% in Västerås to under 5% in Uddevalla. The requirement is especially from new and large residential areas, which are equipped with remote heating, while old housing in city centers frequently remains without remote heating. In numerous cities where remote heating is being developed there are now plans for including inner city housing, or a part thereof, in remote heating.

Future connections for residential heating are planned to be very extensive. For the inner city sections of Östermalm and Norrmalm in Stockholm, plans have been made to be 80% connected by the year 1978. Linköping is estimated to be 80% connected in 1973, and 90% in 1978, Uppsala expects to be 97% connected in 1978, to name some examples. Similar, extensive expansion plans are under way for many other, densely populated places (see Appendix 2).

In accordance with reports from heating plant groups the total connected heat requirement for the 1957-1967 decade has increased from 375 to 2135 Gcal/h, an increase of over 600%.

The connected requirement for the year 1978 is calculated at about 7000 Gcal/h (at the present rate of expansion), or 15000 Gcal/h (for accelerating rate of expansion).

Long-term expansion plans have been made, at the most, for approximately ten locations.

Table 5. Statistical data from member plants concerning work-year 1966/67

City, community	Population in city	Population in distr.	Year built	Connect. heat req. Mcal/h	Energy consumpt. Mwh	Heating medium
Borås	69 443	—	1959	95 887	71 428	hot water
Göteborg	443 292	—	1953	223 982	79 313	»
Halsingborg	79 450	15 000	1964	47 850	—	»
Karlstad	51 975	800	1948	12 490	1 899	»
Linköping	77 365	45 000	1954	190 200	133 101	»
Lund	49 635	—	1963	37 940	—	»
Malmo	253 502	—	1951	413 593	205 565	»
Molndal	30 647	4 500	1963	10 800	—	»
Norrköping	94 067	50 000	1951	128 600	100 970	»
			1939	11 200	8 017	steam
Solna	57 436	5 500	1963	19 839	—	hot water
Stockholm (inkl. Järfälla)	777 115	—	1953	310 000	60 785	»
Sundbyberg	28 707	11 000	1953	31 800	487	»
Uddevalla	36 553	—	1966	3 000	—	hot water and steam
Uppsala	94 587	60 000	1961	157 577	—	hot water
			1962	9 000	—	
Västerås	107 048	90 000	1954	375 200	367 567	»
Örebro	86 003	—	1956	206 000	—	»
Österhaninge	20 850	—	1964	32 570	—	»

Sulfur dioxide and soot from local heating

Up until the beginning of the year 1968 soot and/or sulfur dioxide measurements were made in 24 densely populated localities (Table 6).

During the next years reports were received from Eskilstuna and Partille concerning sulfur dioxide and soot measurements.

The Swedish standard toleration values for sulfur dioxide content in outside air was exceeded in 11 localities. In a few of the localities checked, such as Vasteras, it was held within valid norms.

Table 6. Past and present soot and sulfur dioxide research results. Yields valid as of October 30, 1968

Community	Date	Pollution
Borlänge	present	SO_2,soot[1]
Borås	"	SO_2,soot[1]
Fagersta	"	SO_2,soot[1]
Göteborg	ongoing since 1959	SO_2,soot
Halmstad	1968	SO_2,soot[1]
Hälsingborg	1966—1967	SO_2,soot
Järfälla	1967	SO_2
Jönköping	1966—1967	SO_2,soot
Karlshamn	1964—1965	SO_2
Karlstad	present	SO_2,soot
Lidingö	1964	SO_2,soot[2]
Linköping	1967	SO_2,soot
Lund	1967—1968	SO_2,soot
Malmö	1967	SO_2, soot
Mölndal	1962—1967	SO_2, soot
Skövde	1962—63, 1964—65	SO_2, soot
Solna	1963—1964	SO_2, soot
Stockholm	ongoing since 1962	SO_2 [3]
Trollhättan	1968	SO_2, soot[1]
Täby	present	SO_2
Uddevalla	1965—1966	SO_2, soot
Vänersborg	present	SO_2, soot[1]
Västerås	1965—1966	SO_2, soot
Örebro	present	SO_2, soot

1 Also measurement of suspended particles
2 Also measurement of nitrogen oxides
3 Measurement of suspended particles, 1962-63 and 1964-65

SO_2 measurements were made in the immediate vicinity of the following industries:

Huskvarna Armaments Plant	1964
Mo and Domsjö (Själevad)	1966-1967
Rönnskärs Works	1968

Table 7. Swedish standard values for tolerable sulfur dioxide contents in outside air

Time measured	Content in pphm*	Remarks
1 month	5	Not to be exceeded
1 - 24-hour period	10	Not to be exceeded more than once a month
30 minutes	25	Not to be exceeded more than 15 times per month (1% of the time period

* pphm - parts per hundred millior ($cm^3/100m^2$)

The high content was obtained during the heating season between September and April, and especially December-February. Figure 1 shows sulfur dioxide contents in average monthly values in 1967 obtained at a measuring station in the Klara section of Stockholm.

The typical seasonal variations are very evident in Stockholm (Fig. 1), which in December-January has average monthly values up to, and exceeding daily average values (Table 7). During the summer months of May to September values in excess of the Swedish standards have not been found.

The same seasonal variation is found with respect to soot contents. Research up to the present has shown values of g soot/m^3 excesses in Göteborg and Skövde. A compilation of the most important measurement results of air tests made will be found in Appendix 3.

Up to the present, the highest average monthly values have been reported from Stockholm, where in January 1968 the sulfur dioxide content rose to 15.8 pphm, and the average daily value of 10 pphm was not exceeded less than 24 times (see Table 7). It should be noted, however, that the average temperatures were considerably below normal.

The highest daily averages were reported from Linköping in February 1967, at the time the city was subject to a half-week long inversion, in which contents of 49.3 and 47.6 pphm were recorded. Here it was indeed a matter of exceptionally high values.

According to all research, where measurements were taken at several stations, the central parts had the highest sulfur dioxide content. Analyses of Sweden's energy supply show that heating oil was used for about 90% of all community heating, and 40% of this was heavy oil. For central areas one may also state that this percentage is higher.

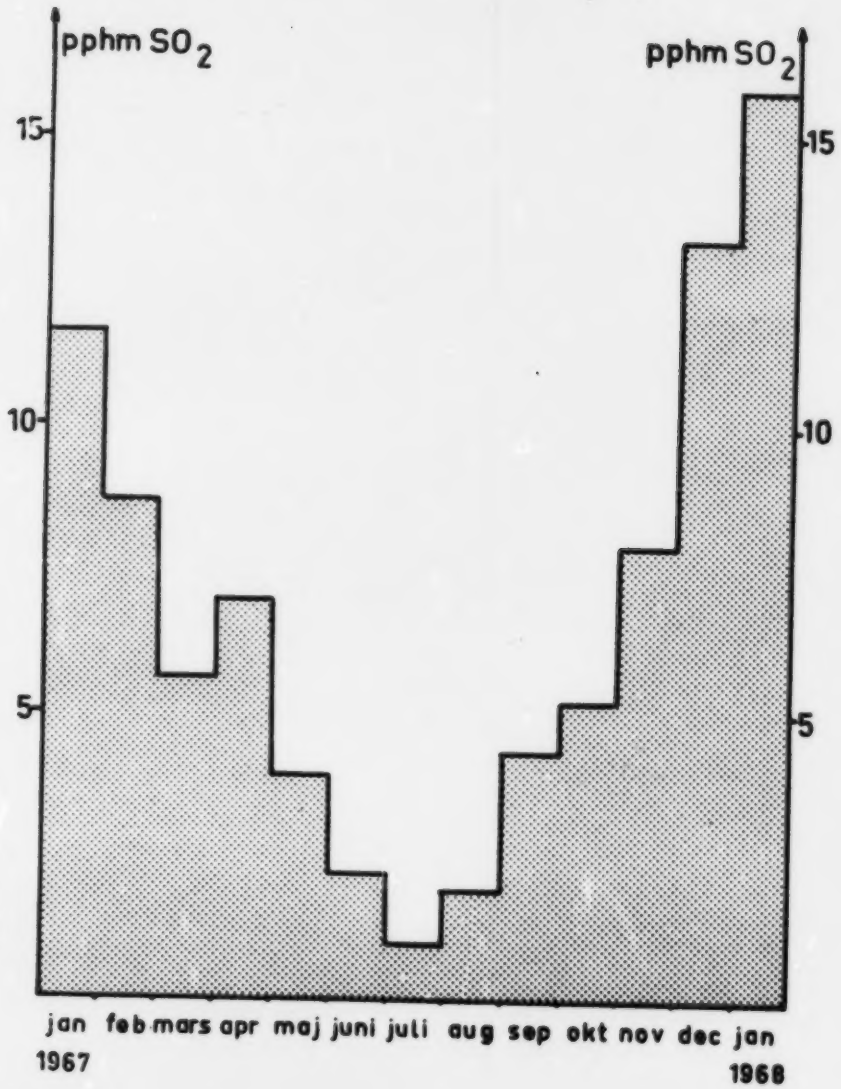

Figure 1. Occurrence of sulfur dioxide at a centrally located measuring station (Klarabergsgatan) in Stockholm in 1967.

Air pollution and centralized heating

A strong reduction in sulfur dioxide contents is noted in central sections with a large remote heating network in comparison to similar places without remote heat.

Noticeable effects were observed in Västerås, Uppsala and Lund, where remote heating capacity was enlarged.

In the years 1966 and 1967, the remote heat system in Uppsala increased from 25% to over 50% of the city's total heat requirements. Above everything, installations strongly increased in 1967. Sulfur dioxide measurements, made for the years 1966-67 and 1967-68, in the same locality in Uppsala, show an impressive decrease in SO_2 content, as seen in Figure 2. In December 1967 and January 1968, the mean temperatures were lower than during the same time the previous year, so that the decreases were the result of the greatly extended remote heating system.

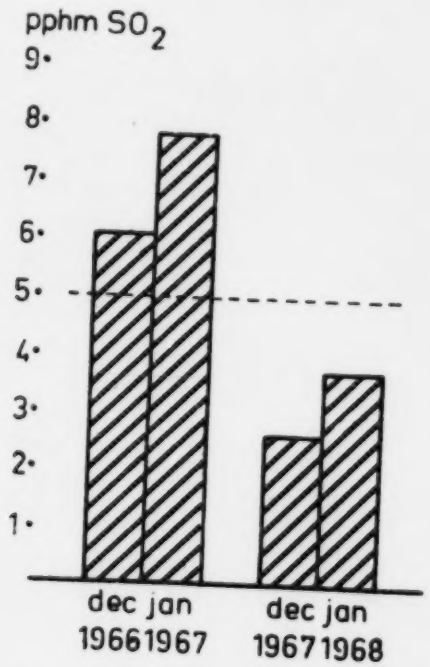

Figure 2. Presence of sulfur dioxide at a centrally located measuring station (Drottninggatan) in Uppsala at end of 1966/beginning of 1967, and end of 1967/beginning of 1968. The stippled line indicates valid standards.

A clear proof are the SO_2 measurements made in December 1966 in seven cities in Sweden (Fig. 3). Five of these had monthly average values in excess of those recommended, and a sixth city showed values just below. Västerås, on the other hand, had considerably lower contents despite the fact that the city is comparable with both Uppsala and Hälsingborg as far as size is concerned. Västerås is 98% connected to the remote heating system for residential heating, and about 60% for industrial use (information as of January 1, 1968). The other cities have not nearly the same remote heating capacity (Fig. 3). However, Uppsala as seen in Figure 2, shows better values for the turn of the year 1968. It is also seen that Västerås has lower SO_2 contents than Karlshamn, which according to the 1964 community list had ten times fewer inhabitants (see Appendix 3).

The significance of remote heating versus private heating has also been shown by a Public Health Board study in Lund concerning air pollution, made for the period January-June, 1967. This study shows concentration differences for three residence types: inner city buildings without remote heat, suburban housing with individual heating, and residential area with remote heat. The results may be seen in Figure 4, where February and March monthly values are given in the diagram columns. It is worth noting that the suburban residential area showed higher

content despite the use of light heating oil with a low sulfur content.

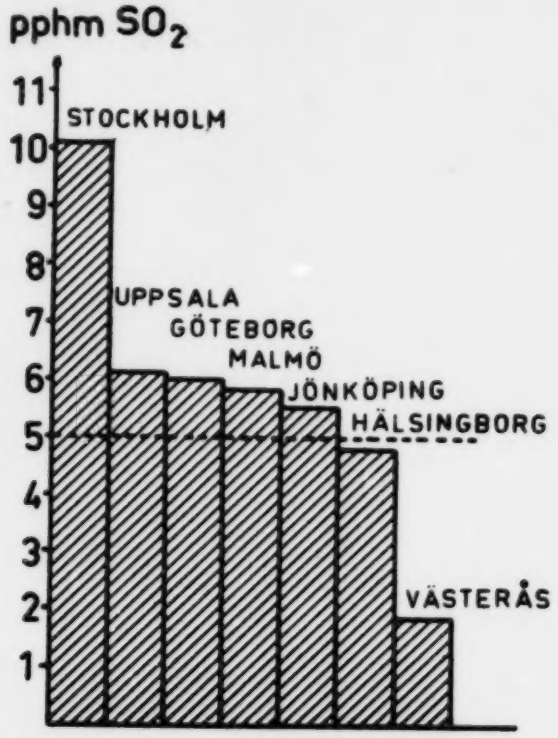

Figure 3. Presence of sulfur dioxide at a centrally located measuring station ir seven Swedish cities in December 1966. The stippled line indicates the national standard.

Mapping projects undertaken show that the air pollution situation concerning both sulfur dioxide and soot from local heating is unsatisfactory in the majority of major cities. However, one can state that the deterioration which occurred during the first half of the 1960's in many ways appears to have stopped. Figures 5 and 6 show the

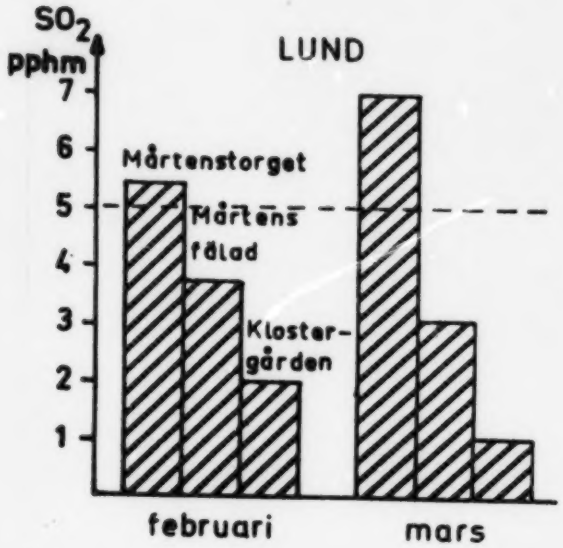

Figure 4. Presence of sulfur dioxide at three measuring stations in Lund during February-March 1967. Martenstorget represents the center of the city with less heavy and light oil heating centers. Martens is the suburban section and Klostergarden the residential area with remote heating. The stippled line represents valid standards.

amount for a centrally located measuring station in Göteborg (Station No. 10, see Appendix 3), where the air quality in regard to sulfur dioxide and soot has improved. Mappings also show that through selection of an appropriate heating system it is possible to achieve significant improvement.

Advantages of central heating plants from the standpoint of clean air

In the case of densely populated areas it is generally better to have centralized heating facilities than several smaller units. Since this condition is not self-explanatory, let us show some causes. Figure 7 shows a schematic diagram

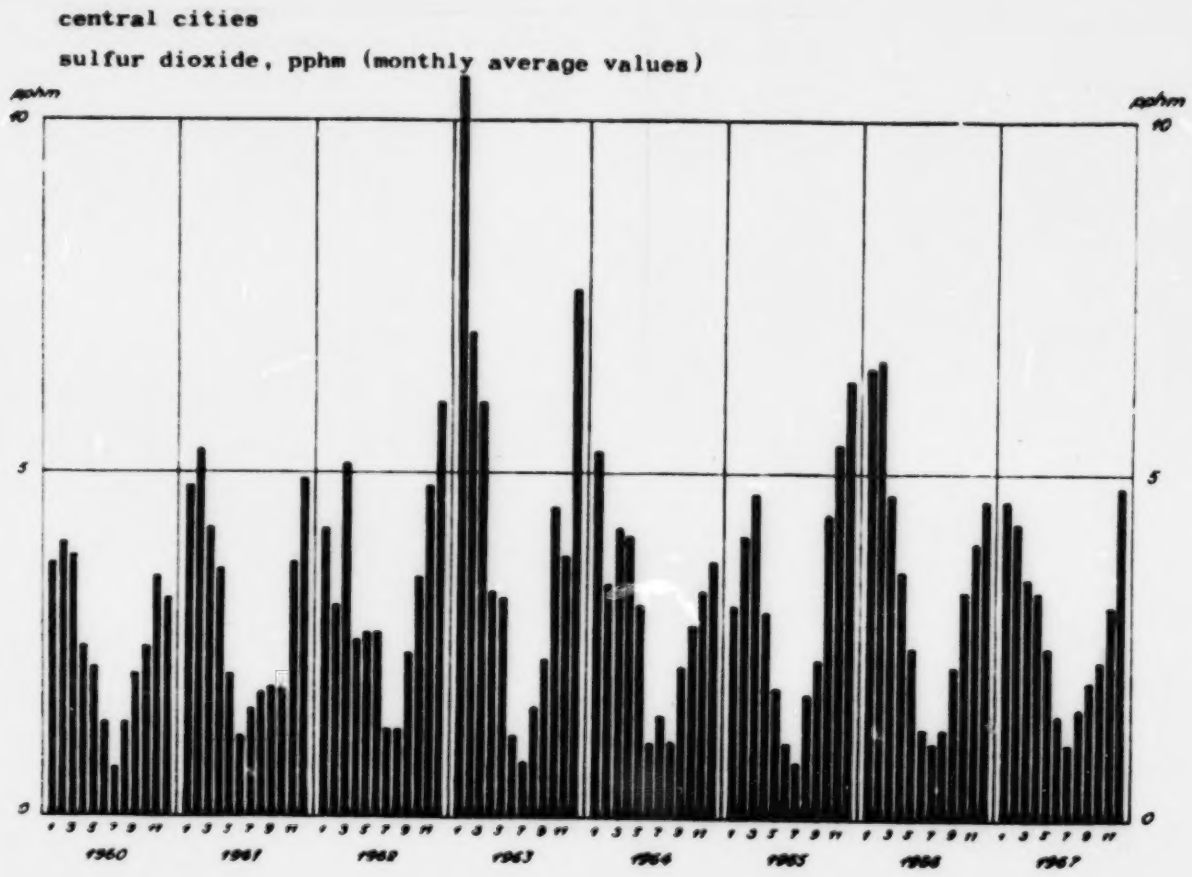

Figure 5. Presence of sulfur dioxide at a centrally located measuring station (Central Station) in Goteborg from 1960 up to and including 1967. The horizontal lines represent valid national standards.

of a city. The number of dots mark the position of similar smaller heating installations. An elliptical figure is drawn in connection with each point. They refer to isolines for a certain concentration in level, for example 10 pphm.

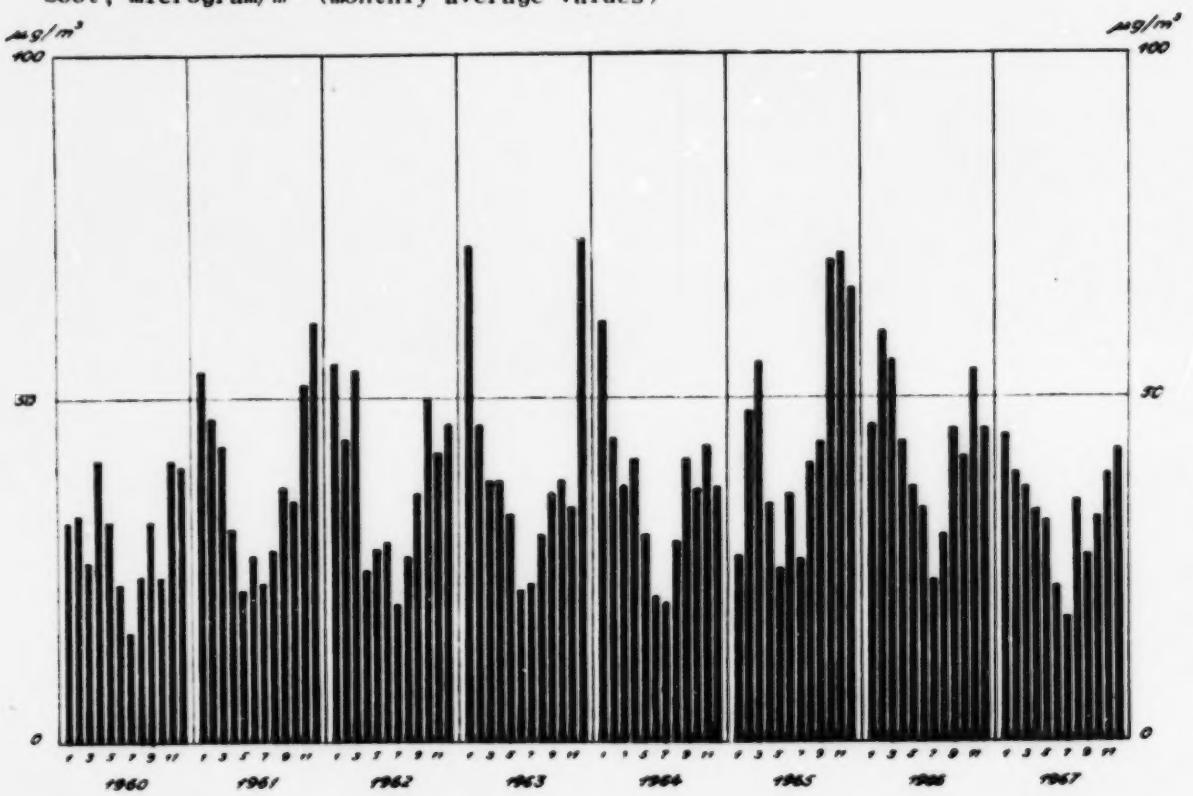

Figure 6. Presence of soot at a centrally located measuring station (Central Station) in Goteborg from 1960 up to and including 1967.

These ellipses sometimes are superimposed over each other, and as a result many city sections are within the 10 pphm limit. In Figure 7 a complete square marks the location of an assumed measuring station for the continuous registration of sulfur dioxide, and the diagram in the same figure illustrates its assumed registrations schematically over a period with even and high heating at all installations.

Of course, constant fluctuations are found, but the mean value lies in the high range.

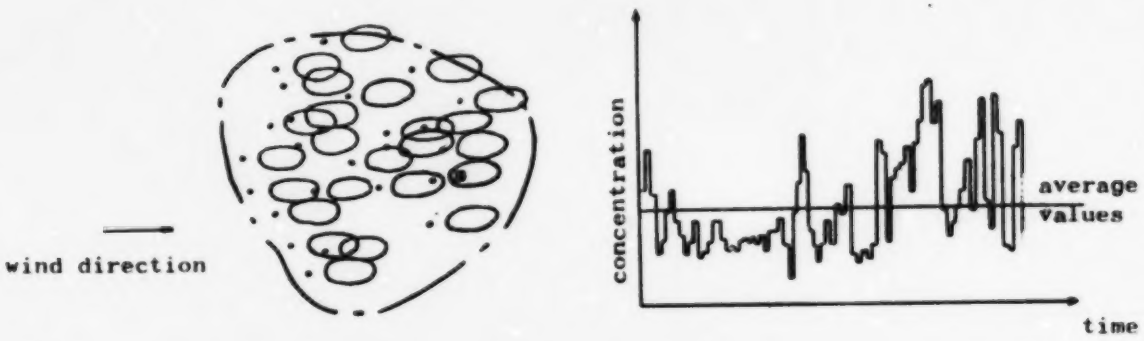

Figure 7. Schematic diagram of a city with decentralized heating system. The points mark the location of neighborhood heating centers. The elliptical figures form isolines for a given concentration of sulfur dioxide at ground level. The diagram above shows assumed concentration of sulfur dioxide recorded by the measuring station designated by the square.

A full circle in Fig. 8 designates a remote heating plant which is to replace the smaller units. An isoline ellipse some distance from the source, in the direction of the wind, indicates a 10 pphm ground level concentration. With the given wind direction, maximum registrations are obtained at the measuring station marked by a square. The winds generally change no more than 5 to 10 degrees, so that the concentration at the measuring station may decrease to zero, and the concentration may be zero when winds blow from all directions perhaps varying 20 degrees in the sector. Thus the air is practically free of sulfur dioxide

90% to 95% of the time, so that the mean value remains low (Fig. 8).

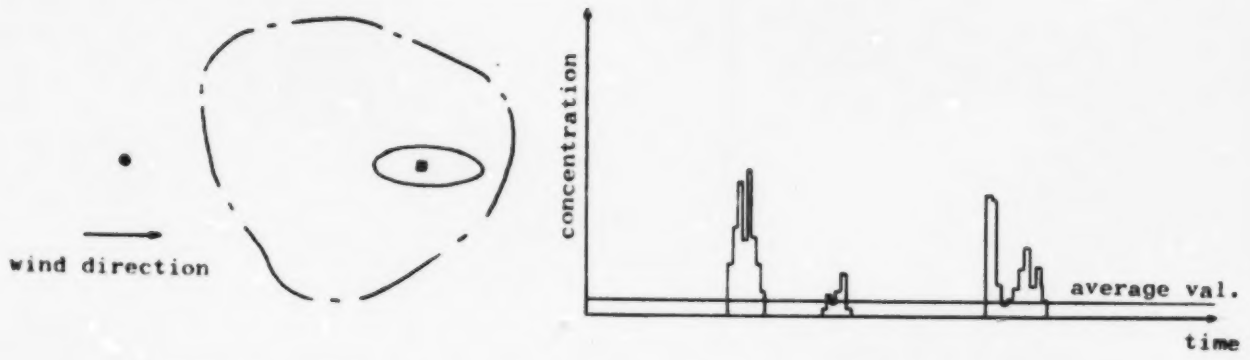

Figure 8. Schematic diagram of a city with centralized heating (compare with Fig. 7). The full circle marks the location of a remote heating plant and the elliptical figure indicates isolines for a given concentration of sulfur dioxide at ground level. The diagram above shows assumed concentration of sulfur dioxide, recorded by the measuring station designated by the square.

The question then is what the peak concentration would be. We might also pose the question of how much pollution can be emitted by a remote heating plant with a reasonably tall chimney, such that the peak concentration will not exceed that for small central heating plants. The following typical values are used in our estimated calculation (designations as in Figure 9).

By using the formula set forth in Figure 9, maximum concentration = Q/H^2, Q yields the SO_2 quantity emitted from the heating installation, and q is the amount of SO_2 from

the small heating plant, we obtain Q = 100 q. The result implies that in this example one can emit 100 times the quantity of sulfur dioxide from a remote heating plant than from the smaller plants without receiving higher concentration peaks at ground level.

Periods of stagnation

Some winters pronounced periods of stagnation occur in our country. Mainly these are caused by (1) winds are very slight, and (2) air is stabilized in layers, i.e., there is inversion in the atmosphere between 500 and 1000 m. Periods of stagnation at our latitudes may last for a week or more at a time. Inversions move over a city in the lowest layer, 50-200 m, depending on the city's size, for one thing. The diagram in Fig. 10 illustrates this condition. Periods of stagnation occur most often in connection with cold weather. Much pollution occurs because of the need for increased heating. Let us first assume that heating is done conventionally, i.e. decentralized. The gentle winds cause the dilutions to remain from day to day. An inversion may lie as a "lid" over the city preventing pollution from moving to a higher level of air (Fig. 10). During a period of stagnation pollution levels generally rise continuously as long as the stagnation lasts.

When all local heating is tied into one central plant, the latter may be equipped with a tall stack. This brings

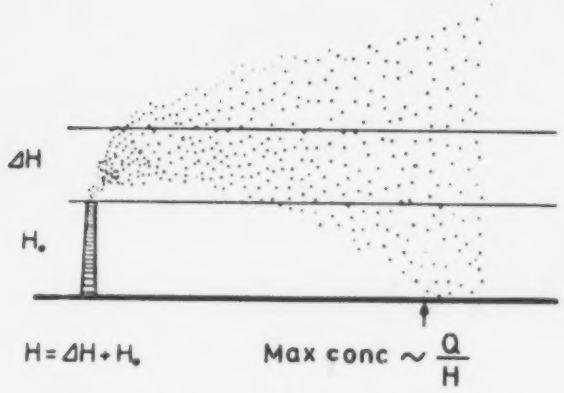

Figure 9. Effective chimney height, H, is the sum of physical height of chimney and rise of the stack gases. Maximum concentrations at ground level are directly proportional to amount at source and conversely with the square at effective chimney height.

Small central heating plant:

Chimney height, h_o = 5 to 15 m, thus 10 m
Chimney addition, Δh_o = 5 to 15 m, thus 10 m
Effective chimney height, h, therefore 20 m

Remote heating plant (heating installation):

Chimney height, H_o = 80 to 150 m, thus 100 m
Chimney addition, ΔH_o = 50 to 400 m, thus 100 m
Effective chimney height, H, therefore 200 m

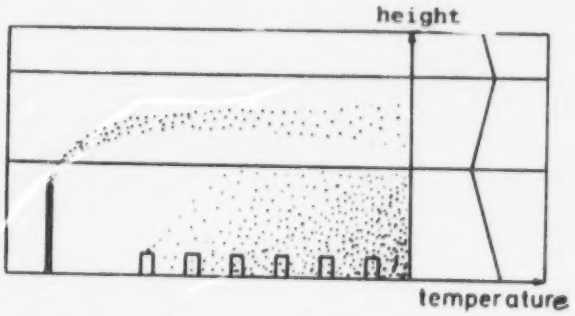

Figure 10. The situation in a city with pronounced stagnation conditions. The above diagram shows inversion layer relationship to temperature gradients.

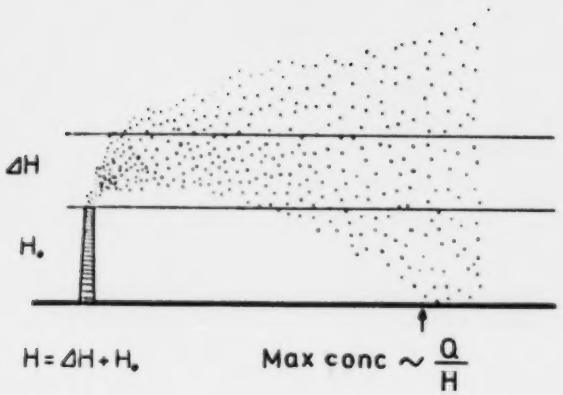

Figure 9. Effective chimney height, H, is the sum of physical height of chimney and rise of the stack gases. Maximum concentrations at ground level are directly proportional to amount at source and conversely with the square at effective chimney height.

Small central heating plant:

Chimney height, h_o = 5 to 15 m, thus 10 m
Chimney addition, Δh_o = 5 to 15 m, thus 10 m
Effective chimney height, h, therefore 20 m

Remote heating plant (heating installation):

Chimney height, H_o = 80 to 150 m, thus 100 m
Chimney addition, ΔH_o = 50 to 400 m, thus 100 m
Effective chimney height, H, therefore 200 m

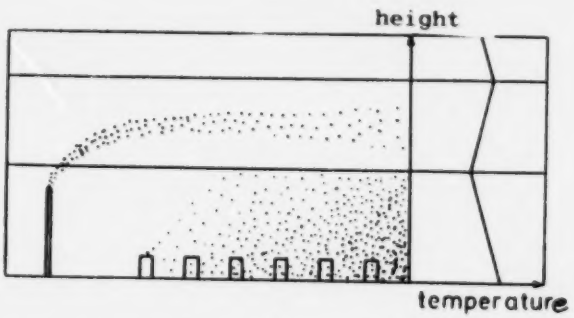

Figure 10. The situation in a city with pronounced stagnation conditions. The above diagram shows inversion layer relationship to temperature gradients.

with it the fact that the stack either extends up into the inversion layer or that in each case the warm smoke rises into it. Smoke is trapped in the inversion layer or will be carried upward several hundred meters. Smoke plumes do not reach the ground until perhaps several tens of kilometers from the source. In such cases the smoke will be greatly diluted as the plume quickly expands in the vertical or horizontal direction in the inversion. Air in the city thus remains free of pollution during a period of stagnation. The not unusual objection that the air pollution problem is only transferred from one place to another by means of a tall chimney, is not relevant. Benefits derived from central heating from the air protection viewpoint can be summed up as follows.

1. Emission of certain pollutants can be reduced by proper combustion and effective ash separation at the source;

2. Tall stacks plus a large amount of warm flue gases result in great effective chimney height, which causes

a. very low mean concentration values to such an extent that 90 to 95% of the time a place may be free of pollution;

b. even existing concentration peaks may be held to acceptable levels;

c. clean air when there is a stagnant period.

Local topography and meteorology will help to determine the height and dimensions of the stack for maximum control of pollutants. The possibilities for coreect calculations of this type are good.

It should be exphasized however that emission at great height is not the final solution for a community heating problem. The height of the chimney is the complement and not a substitute for decrease in total emissions. Therefore parliament has recently decided on a limit for sulfur content in oils if no special flue gas cleaning is used. The reason for this decision is that technical methods are now available for desulfurizing oils and flue gases and that present acidification of fallout demands attention.

General points of view on selection of heating systems

The socioeconomic optimum heating system is not the one based on the lowest costs, but should be decided after proper calculation of the chimney top. The emission of flue gases, primarily containing sulfur dioxide and soot and even nitrous gases and ash particles, produce costs for society through health and disadvantage effects, contamination and corrosion. The Corrosion Institute calculated the cost of air pollution causing metal corrosion in 1960 to be about 500 million kroner per annum. The greatest percentage of corrosion damage occurred in localities where

flue gases from oil-heated heating centers are the most corrosive discharge.

Our Energy Committee's report estimates the heating requirements for residential housing as 80% of the total heating requirements of community heating. In calculating in round numbers the number of residences in cities at 2 million, we obtain a "corrosion cost" of 150-200 kroner per annum, or 30-50% of the total heating costs for a normal residence. Nevertheless, the corrosion costs are only a part of the total "damage cost." Sample calculations show that a city's heating system must be selected such that the sum of heating and damage costs, are as low as possible. The solution to the problem lies in the fact that centralization of local heating will provide an improvement both as to heat and damage costs. Cost differences between small heating installations of the neighborhood center type, and large installations, so-called city quarter central plants, are small and very often it is evident that such a centralization is justified. This brings about significant improvement from the standpoint of clean air values. For cities of from 25,000 to 50,000 inhabitants it may be recommended to go one step further, since heating data show that it is possible to combine production of heat and electric power in so-called power heating plants. The use of central heating plants in the

three largest, densely populated areas showed the central power plant to be the most economically adaptable.

In this connection it should be underlined that electric heat, from the clean air point of view, has all the advantages of remote heat, particularly since in the future electricity will primarily be produced in nuclear power plants. Under the condition that decreased distribution and administrative costs are calculated per kWh, something that is inherent in electric heat, it will be possible to establish a rating structure that already today is in many ways competitive with oil heating. Areas with multi-family housing in the outer areas of larger cities have higher costs for hot-water pipelines from power and central heating plants, and for many groups of small housing clusters the electric heating alternative will be the object of special analyses. The construction of smaller oil-using heating plants in "outer districts" of large cities shows that the favorable effects of central heating in the center city decrease.

Gas heating, just as remote heating and electricity, is considered good heating as far as the environment is concerned.

Reduction of sulfur dioxide emission

Parliament has decreed that as of July 1, 1969, the highest permissible sulfur content in oil may not exceed

2.5%. Oils with a higher sulfur content will be permitted to be used only if the emission is reduced to 50 g sulfur dioxide per kg of oil by flue gas cleaning. The National Environmental Protection Service has made a proposal that by October 1, 1969, after contact with concerned parties, there will be a program for additional lowering of sulfur dioxide emissions.

The possibility that local Public Health ordinances will introduce regulations about highest permissible sulfur dioxide emissions was considered in Stockholm (Appendix 4). A proposal concerning Göteborg has been submitted (Appendix 5). This method, which makes possible a swift lowering of sulfur dioxide in outside air, is well-founded where the contents exceed the prevailing standards. Restraint should be shown in setting up for local regulations, so that these may be incorporated to best advantage in a program for the country in general. Increased community engagement with respect to local heating appears desirable even in smaller cities.

Appendix 1

LOCALITIES CONCERNED DIVIDED INTO COUNTIES

	Pop. in thousands 1 jan 1965
Stockholms city	793
Stockholms county	
Botkyrka district	16
Huddinge district	41
Järfälla district	35
Lidingö	34
Nacka	24
Sollentuna community	32
Solna	55
Sundbyberg	28
Södertalje	44
Täby community	28
Österhaninge district	15
Uppsala county	
Enköping	16
Uppsala	84
Södermanlands county	
Eskilstuna	62
Katrineholm	21
Nyköping	28
Östergötlands county	
Finspång	17
Linköping	71
Motala	28
Norrköping	93
Jönköpings county	
Huskvarna	15
Jönköping	53
Nässjö	19
Tranås	16
Värnamo	15
Kronobergs county	
Växjö	29
Kalmar county	
Kalmar	36
Västervik	19
Gotlands county	
Visby	17
Blekinge county	
Karlskrona	32
Kristianstads county	
Hässleholm	15
Kristianstad	27
Malmöhus county	
Hälsingborg	78
Landskrona	29
Lund	44
Malmö	246
Trelleborg	21
Hallands county	
Halmstad	41
Varberg	16
Göteborgs county	
Göteborg	419
Mölndal	30
Partille	20
Uddevalla	36
Älvsborgs county	
Alingsås	19
Borås	69
Trollhättan	35
Vänersborg	20
Skaraborgs county	
Falköping	16
Lidköping	18
Skövde	27
Värmlands county	
Arvika	16
Karlstad	47
Kristinehamn	21

	Pop., in thousands 1 jan 1965
Örebro county	
Karlskoga	37
Örebro	80
Västmanlands county	
Fagersta	16
Köping	19
Västerås	85
Kopparbergs county	
Borlänge	28
Falun	19
Ludvika	22
Gävleborgs county	
Bollnäs	17
Gävle	60
Hudiksvall	16
Sandviken	23
Västernorrlands county	
Härnösand	17
Själevad	19
Sundsvall	58
Örnsköldsvik	16
Jämtlands county	
Östersund	25
Västerbottens county	
Skellefteå	23
Skellefteå district	20
Umeå	47
Norrbottens county	
Boden	15
Gällivare-Malmberget	27
Kiruna	28
Luleå	34
Piteå	15

Appendix 2

REPORT OF PRESENT REMOTE HEATING SITUATION IN CITIES AND A PROGNOSIS FOR THE NEXT DECADE

Borås

Connected heat demand on January 1, 1968 was 99 Gcal/h, which covers about a third of the total heat requirement. The yearly increase is calculated at 15 Gcal/h. In 1973 the connected heating demand is calculated to be in the vicinity of 175 Gcal/h, and by 1978 at about 300 Gcal/h, which will mean that the greatest part of Borås will be in the connected heating system.

Eskilstuna

City authorities have decided on expanding remote heating in the city. The first large boiler plant will be set up in 1970. In 1973 connections for heating use will be up to 70 Gcal/h, and in 1978 to 250 Gcal/h. Both central sections and new suburbs will receive remote heat according to plan.

Gävle

Krångede AB has received the concession for the nuclear power plant at Långharen. For the Gävles section the number of heating connections will be at about 100 Gcal/h in 1973, and about 200 Gcal/h in 1978, and also will include a number of block centers. The nuclear power plant is expected to be ready in the 1980's.

Göteborg

The Göteborg Power Plant had, as of January 1, 1968, a connected heating requirement of 400 Gcal/h. 602 housing connections were made in the city's 17 central city sections, and 1538 were not connected. Continued building is anticipated very quickly and 75% of the city's heating needs is expected to be connected in 1970 (820 Gcal/h). By the year 1975 even far outlying areas are expected to be included (Partille, Örgryte, for example).

Hälsingborg

Connected heating demand in January 1968 was 133 Gcal/h. All new multifamily housing will be connected. Existing houses in the central city are for the most part expected to be included before 1973. In 1978 the connected heating needs are expected to amount to about 400 Gcal/h.

Karlstad

Karlstad is Sweden's oldest city with remote heating, but which is not very extensive. In January 1968 output was 12.5 Gcal/h. Certain new industrial areas will be supplied with remote heat.

Linköping

Of the total heating demand of Linköping, it was calculated that as of January 1, 1968, 60% were connected to

the remote heating system. The city's central parts are included. Planned building on the outskirts will be connected to the remote heating network. It is calculated that by 1973 the power-heating plant will supply 80% of the total heating needs and 90% by the year 1978 (450 Gcal/h).

Lund

The connected heating demand rose to 38 Gcal/h as of July 1, 1967. A good 10% of the inner city's heating needs are in the net at present. By 1973 it is estimated that expansion will have more than doubled, and by 1978 quadrupled. From now on all new areas on the city's perimeter will be supplied with remote heat.

Malmö

The connected heating needs as of January 1, 1968 were 415 Gcal/h and the prognosis for 1973 goes to 770 Gcal/h and for 1978 to between 960 (minimum) and 1210 Gcal/h (maximum). Expansion will also double or treble within ten years.

Mölndal

The connected heating needs in 1967 were 10.8 Gcal/h. Expansion is planned for the city's western parts. By 1973 it is estimated that connections will have more than a five-fold increase.

Norrköping

About 25,000 residences are heated by remote heat as of January 1, 1968. Future expansion is planned in the Vilbergen, Navestad and Marielund city sections. Connected heating on July 1, 1967 amounted to 140 Gcal/h and it is estimated to be about 275 Gcal/h and 425 Gcal/h in 1973 and 1978, respectively.

Solna

The Solna city heating plant as of January 1, 1968 produced a good 30 Gcal/h, including (trash) burning. Heavy expansion over the next five year period is estimated to lead to a five-fold increase in connected heating.

Stockholm

Stockholm and its environs has at present three remote heating plants, at Hässelby, Vårtan and Ågesta. In the Hässelby and Vällingby areas there is an almost 100% tie-in, as is also the case in the Ågesta-Farsta area.

During 1968 parts of Östermalm and lower Norrmalm were connected, up to a 40% total. The total connection during 1967 rose to 320 Gcal/h.

By 1973 Östermalm is scheduled for an 80% tie-in and parts of Norrmalm for 30%, and by 1978 even lower Norrmalm will reach 80%.

In accordance with the latest plan for development, the Stockholm area will be provided with three large remote heating plants: one in Vårtan (nuclear power), one in Kallhåll (nuclear power) and the third more to the south of Stockholm. Even Solna, Sundyberg and Järfälla will join in the remote heating network, at which time the present works will be put into service as peak-use plants.

Sundyberg

Connected heating demand rose to 90 Gcal/h by July 1, 1967 and by 1978 the connection effects will cause a rise to about 125 Gcal/h.

Uddevalla

The connection value for Uddevalla is estimated to rise to 30% of the total heating requirement by 1978.

Umeå

The remote heat expansion program for Umeå started two years ago and the connected heating demand was about 5 Gcal/h in 1967. By 1973 it is estimated that it will amount to 50 Gcal/h and in 1978 to about 100 Gcal/h.

Uppsala

The heating plant's connection effect amounted to 200 Gcal/h by January 1, 1968, which corresponds to about

50% of the total heat consumption. It is estimated that about 90% or more of the heating requirements for the city will be connected to the remote heating plant by 1978.

Västerås

Connections to the remote heating plant by January 1, 1968 amounted to about 98% and for industries to about 60%. As of July 1, 1968, additional industries will be connected to the source, so that 90% of the industrial heating needs will be met by remote heat. All planned industrial and residential areas within the region will be connected.

Örebro

206 Gcal/h was connected as of January 1, 1967, or about half the total demand.

Continued connection will be made both in the central and outer areas and it is estimated that about 470 Gcal/h will be supplied in 1973, and about 600 Gcal/h in 1978.

Appendix 3

RESULT OF SOOT AND SULFUR DIOXIDE MEASUREMENTS IN SWEDEN

Only the average monthly values from the most recent years are reported. Numbers in bold face indicate values in excess of the average monthly value of 5 pphm for sulfur dioxide and 50 g/m^3 for soot. The figures in parentheses show the number in excess of the daily mean value of 10 pphm for sulfur dioxide and 50 g/m^3 for soot.

For further information on measurements, consult public health authorities of the respective cities.

The measurements were made, with a few exceptions, by Professor Cyril Bross of the Swedish Silicate Research Institute, Göteborg.

Göteborg

Monthly average values for sulfur dioxide, pphm, Jan-Dec 1965

Statn.	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1											1,9	2,9
2											3,3 (1)	3,8 (2)
3											4,0 (2)	4,5 (3)
4											**5,2** (3)	5,0 (3)
5											4,6 (2)	**5,6** (3)
6											**5,9** (3)	**5,9** (4)
10	3,1 (1)	4,1 (1)	4,7 (1)	3,0	1,9	<1,1	<0,8	1,8	2,3	4,4 (1)	**5,4** (2)	**5,8** (3)
11					2,8							

Göteborg 1966 SO,

Statn.	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	2,7	2,4	<1	<1	0,8	<0,5	<0,4	<0,5	<0,5	0,9	1,7	1,6
2	3,9 (2)	2,8	0,9	1,2	1,0	<0,6	<0,4	<0,6	<0,6	1,6	2,4	3,0 (2)
3	4,0 (2)	4,2 (2)	<1	<1	1,2	0,7	0,7	0,7	<0,7	1,6	2,4	2,9
4	**5,6** (3)	**5,7** (3)	1,4	2,4	1,5	<0,8	0,6	0,9	<1,0	2,9	3,6	3,7 (2)
5	**5,9** (3)	**6,0** (5)	1,9	2,5	2,3	0,9	0,9	0,8	<1,0	2,7	3,0	3,9 (2)
6	**6,1** (3)	**6,8** (5)	2,2	2,6	1,7	1,3	0,8	0,8	1,6	2,7	3,4	**5,1** (2)
10	**6,5** (3)	**6,6** (5)	4,7	3,6	2,5	1,3	1,1	1,3	2,2	3,3	4,0	4,6 (1)
11	—	—	4,8	**5,3** (2)	3,3	3,3	2,6	2,7	2,5	4,3	4,8 (1)	**6,0** (2)

Göteborg 1967 So,

Sta.	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	1,9	1,7	0,4	0,9	0,9	0,2	0,3	0,2	0,7	0,4	1,3	—
2	2,9	1,8	0,6	1,3	1,4	0,4	0,3	0,6	1,0	0,5	1,4	2,5
3	2,6	1,7	0,4	1,4	1,6	0,5	0,9	0,7	1,4	0,9	1,6	1,9
4	3,6	2,3	1,4	1,9	1,7	1,1	0,4	0,7	1,6	0,9	1,7	3,3
5	3,5	2,5	0,9	2,1	1,7	1,0	0,6	1,2	1,5	0,8	2,0	3,8
6	3,7	2,7	1,2	2,6	1,7	1,1	0,8	1,1	1,9	0,9	2,1	4,4 (2)
10	4,6	4,3	3,5	3,3	2,5	1,5	1,1	1,6	2,0	2,3	3,1	4,8 (1)
11	**5,2** (1)	4,2	3,4	3,9 (1)	3,5	3,7	2,6	3,0	2,7	2,4	3,4	**6,9** (2)

Göteborg 1968 SO,

Stn	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	1,7 (1)	1,9	0,5	0,7	0,2	0,5						
2												
3	3,6 (2)	2,7	0,4	1,1	0,7	1,2						
4												
5	**5,4** (4)	4,0 (1)	1,0	1,2	1,2	0,8						
6												
10	5,0 (2)	5,0 (1)	1,9	2,5	1,9	1,3						
11	**7,5** (6)	5,0 (2)	3,3	3,0	2,6	3,2						

Göteborg

Monthly average values for soot, in µg/m^3. Jan-Dec 1965.

Stn	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	3,1 (1)										12,7	20,5 (1)
2											11,7	18,4 (1)
3											16,8	28,9 (5)
4											14,2	23,9 (2)
5											10,5	18,7 (2)
6											19,8 (1)	34,5 (6)
10	26,9 (3)	48,0 (9)	**55,0** (13)	34,5 (8)	24,9 (1)	36,1 (3)	26,5 (1)	40,4 (7)	43,3 (2)	**69,8** (19)	**71,2** (12)	**65,8** (10)
11					20,3							

Göteborg 1966 Soot

Stn	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	23,6 (1)	17,9	9,0	7,1	6,5	5,3	3,5	7,9	7,9	12,5	17,3	14,8 (1)
2	19,3 (1)	22,1	8,9	10,0	9,6	5,9	2,6	6,5	7,3	13,7	21,2	22,1 (3)
3	25,0 (3)	28,1 (2)	11,3	10,5	10,0	7,8	3,4	8,9	9,1	18,4	26,4 (1)	26,1 (3)
4	25,9 (2)	29,6 (2)	11,7	12,8	10,9	7,1	3,4	9,0	9,8	20,0 (1)	25,8 (1)	25,5 (2)
5	25,3 (4)	32,1 (2)	13,1	14,5	11,7	7,4	3,9	9,3	10,8	20,5 (1)	24,9 (2)	25,8 (2)
6	35,8 (4)	41,8 (9)	15,4	18,7	13,8	12,2	6,9	12,1	18,9 (2)	26,8 (1)	34,6 (7)	37,3 (4)
10	45,9 (9)	**59,7** (2)	**55,7** (14)	43,3 (8)	37,1	34,0	23,3	30,1 (3)	45,5 (9)	41,3 (7)	**54,2** (11)	45,3 (4)
11			34,9 (3)	32,1 (2)	25,1	21,9	10,8	18,7 (2)	23,1 (3)	31,2 (4)	31,3 (2)	39,1 (4)

Göteborg 1967 **Soot**

Stn	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	14,4	8,2	6,2	5,3	5,9	2,9	2,5	4,9	7,0	6,6	19,7 (1)	—
2	17,5	9,9	5,3	6,2	8,4	3,7	2,3	5,4	8,1	6,1	13,5	13,5 (1)
3	22,8	11,0	6,8	8,2	9,9	5,3	3,0	7,3	14,1	8,2	17,9 (2)	19,8 (1)
4	24,8	12,1	7,1	5,9	8,9	4,0	2,5	6,0	8,3	4,0	8,5	11,3 (1)
5	24,5	12,5	8,3	9,7	11,8	4,9	2,6	7,0	13,9	8,1	18,1 (1)	21,3 (1)
6	29,7	15,8	9,8	12,5	15,8	11,2	7,2	14,4	24,4	11,5	24,7 (2)	29,4 (2)
10	44,6	39,1	37,1 (4)	33,6 (2)	32,2 (2)	22,6	18,1	34,9 (4)	27,1 (2)	32,3 (3)	38,8 (5)	42,5 (5)
11	32,1 (2)	25,4 (1)	14,3	21,5 (1)	17,9	11,5	7,1	22,4	21,3	13,1	24,8 (2)	35,8 (3)

Göteborg 1968 **Soot**

Stn	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	10,9 (1)	11,6	5,0	7,2	3,8	4,8						
2												
3	24,2 (1)	17,7	7,7	10,7	5,7	8,4						
4												
5	23,6 (1)	19,5	7,6	10,4	6,2	1,0						
6												
10	44,3 (5)	38,8 (6)	31,5 (1)	29,5	20,9	25,5						
11	38,4	35,1 (5)	17,1	21,0	17,8	18,4						

Sampling sites in Göteborg

Station nr	Location
1	Syrhala, Torslandavägen
2	Kärrlyckan, Rödjan
3	Ryaberg, Lilla Rödjan
4	Fågelbroskolan, Vårvädersgatan
5	Bräcke Västergård, Bräckevägen
6	Kopenhamnsgatan, Rosenhills idrottsplats
10	Centralstationen, Drottningtorget
11	Västra Tiden, Otterhälle school

Additional measurement values are found from 15 other stations.

Halmstad

Monthly average values for sulfur dioxide in pphm and soot in µg/m³. Feb-Apr 1968

Station	SO_2			Soot		
	febr.[1]	mars	april	febr.[1]	mars	april
1	2,9	0,7	0,7	18,9	14,9	13,2
2	1,9	0,6	0,6	8,4	7,9	6,6
3	1,9	1,4	1,3	16,0	22,8	13,2
4	0,1	0,8	0,2	4,7	6,2	5,5
5	2,9	1,7	1,1	16,0	12,7	10,6
6	4,6	2,1	1,5	12,4	12,8	13,3
7	—	1,0	0,9	—[2]	9,7	8,0
8	1,2	1,5	1,2	10,6	9,8	9,2

[1] These average values are from the measuring period Feb 12 to 29.

[2] Instrument failure for 5 days.

Sampling sites in Halmstad

Station nr	location
1	the harbor
2	Gattets Campingplats
3	Malou Industri AB
4	Renhållningsverket
5	Sture school
6	Gamla spikfabriken
7	Magnus Stenbecks väg 50
8	Furulund school

Hälsingborg

Monthly average values for sulfur dioxide in pphm. Jun 1966-Jun 1967

Stn	1966 juni	juli	aug	sept	okt	nov	dec	1967 jan	febr	mars	april	maj	juni
1	<1	<1	<1	<1	1,8	2,7	2,2	2,3	2,6	1,5	0,7	1,3	0,4
2	1,0	<1	1,1	1,9	2,4	4,2	4,2	4,4	4,1	2,7	2,2	1,8	1,3
3	1,5	<1	1,4	2,0	3,6	5,1	4,5	4,8	4,2	3,4	2,4	2,6	1,4
4	1,2	1,0	1,4	1,8	2,8	4,3	4,0	4,3	3,7	2,6	2,7	2,3	1,6
5	<1	<1	<1	0,9	1,5	2,4	2,6	2,8	2,9	3,0	1,9	1,2	1,1
6	<1	0,9	<1	1,0	0,9	1,5	1,4	1,2	1,7	1,1	<1	<1	<1
7	1,5	<1	<1	1,9	3,3	5,0	4,8	5,1	5,2	2,9	2,2	2,6	1,7
8	<1	<1	<1	0,9	1,0	2,2	2,2	2,3	2,5	1,8	2,4	1,1	1,2

Sampling sites in Hälsingborg

Station nr	Location
1	Randersgatan 35
2	Fredriksdalsplats 2
3	Fågelsångsgatan 22
4	S. Storgatan 32
5	Tranåsgatan 10
6	Furutorpsgatan 85
7	Fridhemsgatan
8	Industrigatan (Rååverken)

Järfälla

Monthly average values for sulfur dioxide in pphm. Feb-Mar 1968

Stn	febr	mars
Riddarplatsen (Jakobsberg)	6,6 (11 meas.values)	3 (16 meas.val.)

Jonkoping

Monthly average values for sulfur dioxide in pphm. Oct 1966-Jan 1968

Stn	1966 okt	nov	dec	1967 jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec	1968 jan
1	1,5	1,8	1,5	2,0	1,3	0,9	1,1	0,4	0,5	0,2	0,5	0,6	0,6	—	1,6	—
2	1,6	2,2	1,8	0,9	0,8	1,4	1,3	—	—	0,6	0,9	0,9	0,8	—	1,6	—
3	0,6	0,7	0,7	1,6	0,8	—	0,9	0,5	0,2	0,4	0,2	0,3	—	—	0,8	—
4	0,5	0,9	1,3	0,6	0,8	0,7	1,1	0,7	0,5	0,6	0,6	0,5	0,5	—	0,9	—
5	0,6	1,6	1,5	2,8	1,2	0,8	2,1	—	0,5	0,6	0,7	0,9	0,3	—	1,7	—
6	2,1	4,0 (1)	3,7	3,6	3,4	2,0	3,5	2,1	1,1	1,0	1,2	1,8	0,9	—	2,0	—
7	2,1	2,1	2,0	2,5	1,8	1,4	1,3	0,8	0,7	0,5	0,7	0,7	0,6	—	—	2,4
8	2,0	2,6	2,2	2,4	1,8	0,8	1,0	0,4	0,4	0,4	0,9	0,9	0,6	—	—	3,2
9	0,9	1,0	0,8	1,3	0,7	0,5	0,6	0,4	0,3	0,0	0,4	0,4	0,6	—	—	1,3
10	2,0	2,1	2,1	2,5	1,9	2,1	1,7	0,7	0,9	0,4	0,9	1,0	1,1	—	—	2,8
11	4,3	4,6	5,5	4,1 (2)	2,8	3,8	3,5	2,3	1,6	1,4	2,0	2,6	1,2	—	—	4,4

Jonkoping

Monthly average values for soot in $\mu g/m^3$. Oct 1966-Jan 1968

Stn	1966 okt	nov	dec	1967 jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec	1968 jan
1	6,2	13,2	8,7	10,5	8,5	5,7	6,1	4,4	2,7	2,8	5,7	8,8	—	—	7,6	—
2	11,1	15,7	7,7	13,5	10,5	8,5	7,5	—	—	4,2	8,1	12,0	—	—	11,0	—
3	6,0	13,5	6,4	14,3	8,0	—	5,5	7,8	3,3	3,3	5,7	7,4	—	—	8,1	—
4	10,6	13,8	8,5	1,9	6,2	5,8	5,0	6,7	2,8	2,7	4,8	8,3	—	—	6,6	—
5	12,9	14,6	8,3	12,4	8,1	6,1	6,6	—	3,3	2,9	5,8	8,5	—	—	12,9	—
6	11,1	21,9	14,9	18,0	13,5	10,2	14,0	13,0	7,2	5,4	10,8	14,2	—	—	17,4	—
7	9,6	18,1	11,8	12,6	10,0	6,4	6,6	8,7	5,6	4,5	8,6	11,4	—	—	—	12,6
8	11,3	14,1	10,4	10,7	7,3	4,1	2,3	3,4	2,5	2,3	5,4	8,4	—	—	—	14,5
9	4,1	6,3	3,1	5,3	4,3	9,9	15,2 (1)	8,2	5,8	1,5	10,5	11,4	—	—	—	6,0
10	8,3	19,6	17,9	16,5	16,6	13,0	9,9	10,1	6,6	5,1	10,3	13,8	—	—	—	12,4
11	4,0	16,7	13,6	17,9	12,3	11,2	9,2	11,1	7,0	7,0	11,7	14,3	—	—	—	18,1

Sampling sites in "Jönköping"

Station nr	Location
1	Ceresgatan
2	Starrgatan
3	Ryhovs hospital
4	Golfbanan
5	Solbergagatan
6	Sjögatan
7	Spikhammargatan
8	Thorildsgatan
9	S of Ekebergsgatan
10	N Storgatan by Kristina Church
11	Hoppets gränd

Karlshamn

Monthly average values for sulfur dioxide in pphm. Jul 1964-May 1965

Stn	1964 juli	aug	sept	okt	nov	dec	1965 jan	febr	mars	april	maj
1	1,3 (1)	0,5	0,5	0,6	0,5	1,2	2,0	0,8	1,1	0,5	0,4
2	0,3	0,5	0,8	0,9	1,0	—	1,4	1,7	1,5	~0	0,4
3	0,5	0,6	0,5	0,3	0,4	—	0,9	0,6	0,6	~0	0,3
4	0,7	0,8	1,0	1,5	1,0	—	2,2	1,7	2,4	1,3	0,8
5	0,6	0,6	1,2	2,3	2,0	2,9	3,9	3,0	3,0	1,4	0,9
6	0,5	0,6	0,8	1,5	2,0	1,8	1,9	2,1	2,1	0,9	0,8

Sampling sites in Karlshamn

Station nr	Location
1	North section of city
2	Asarum
3	Stillerud
4	City's central sections
5	" " "
6	" " "

Linköping

Monthly average values for sulfur dioxide in pphm. Jan 1967-Oct 1967

Stn	jan	febr	mars	april	maj	juni	juli	aug	sept	okt
1	2,1	7,1 (2)	2,4	1,6	0,9	0,4	0,3	0,5	0,7	0,5
2	3,7	4,9 (2)	1,3	1,2	1,0	0,1	0,6	0,4	0,8	0,4
3	—	3,8	2,3 (1)	1,1	0,8	0,3	0,2	0,5	0,1	0,1
4	3,8	4,4 (1)	2,1	1,7	1,6	0,4	1,0	0,8	1,2	0,6
5	3,1	7,3 (3)	2,7	1,2	0,9	0,6	0,9	0,8	0,7	1,1
6	0,3	2,3	1,1	0,8	0,3	0,1	0,2	0,4	0,3	0,5
7	0,9	2,6 (1)	1,3	0,2	0,2	0,0	0,1	0,4	0,2	0,2

Linköping

Monthly average values for soot in µg/m³. Jan 1967-Oct 1967

Stn	jan	febr	mars	april	maj	juni	juli	aug	sept	okt
1	9,9	14,2	10,8	10,9	8,7	6,2	7,0	9,5	11,7	12,3
2	16,2	16,9 (1)	8,1	10,4	10,0	5,2	5,2	6,3	13,4	10,6
3	17,8	25,2	22,4 (2)	20,9	17,8	19,6	15,1	20,3	26,5 (2)	27,6 (1)
4*)	33,3	34,0 (5)	17,9 (2)	18,2	18,2	12,7	12,8	18,9	24,8 (1)	19,2
5	19,5	25,0	23,0 (2)	26,4 (2)	26,7 (1)	23,0	18,7	29,9 (3)	36,3 (4)	36,6 (5)
6	19,0	16,7	10,7	14,7	11,9	8,6	8,3	11,3	16,7	13,0
7	7,8	6,5	4,1	4,6	3,9	1,9	4,4	5,0	6,2	5,6

*) These measurement point were affected by heavy auto traffic and nearby parking areas.

Sampling sites in Linköping

Station nr	Location
1	Magasintorget
2	City museum by Vasatorget
3	Industrigatan — Gesällgatan
4	Engelbrektsgatan (Bantorget)
5	Tullgrand
6	Ljungstedtska schools
7	Borraregatan

Lund

Monthly average values for sulfur dioxide in pphm. Jan 1967-Apr 1968

stn	jan 1967	febr	mars	april	maj	juni
1	3,6	5,4	7,0 (4)	4,2 (1)	2,2	3,4
2	3,7	3,7	3,1	1,7	1,8	1,9
3	8,6 (5)	5,3 (1)	4,1 (3)	3,0	2,2	1,8
4	1,6	2,0	1,1	1,4	1,0	1,3

	juli	aug	sept	okt	nov	dec
1	1,5	1,7	2,4	3,8	4,6 (1)	6,0 (3)

	1968 jan	febr	mars	april
1	6,9 (8)	5,6 (5)	4,4	4,0

Monthly average values for soot in µg/m³. Jan 1967-Jun 1967.

stn	jan	febr	mars	april	maj	juni
1	40,7	35,6	30,4	21,1	17,9	15,0
2	26,0	14,1	7,9	6,2	6,5	3,6
3	27,6	14,7	10,7	7,2	7,2	3,2
4	20,4	13,5	7,6	5,2	4,4	2,8

Sampling sites in Lund.

Station nr	Location
1	Mårtenstorget
2	Mårtens fälad
3	Kobjer
4	Klostergården

Malmö

Monthly average values for sulfur dioxide in pphm. Mar 1965-Feb 1967.

stn.	mars 1965	okt	nov	dec	jan 1966	febr	mars	okt	nov	dec	jan 1967	febr
1	2,6	1,1	2,1	2,0	3,2	3,2						
2	1,4	0,3	0,4	0,6	1,1	1,4						
3	4,1	1,2	2,3	2,6	3,7 (2)	2,8	2,6	1,1	4,1	3,4	4,3 (2)	1,7
4	2,4 (2)	0,4	1,3	1,1	2,9 (2)	2,6						
5	1,1	0,3	0,4	0,5	0,5	0,5						
6	2,7	0,7	1,7	1,4	2,6 (1)	2,0						
7	2,3	0,9	2,0	1,5	3,6 (1)	2,8						
8								2,7	5,2 (2)	4,0	3,2	2,8
10								3,0 (2)	5,0	—	—	4,5
11								2,1	4,8	1,6	3,1	2,7
13								2,4	4,5	5,3	5,2 (2)	7,4 (3)
14								3,1	6,3	—	—	9,3 (5)
15								1,8	2,4	3,0	3,7 (2)	3,0
16								2,3	5,0	5,8	5,6 (3)	5,6 (2)

Sampling sites in Malmö

Station nr	Location
1	St Andreas church
2	Vaktgatan — Limhamnsvägen
3	Geijer school
4	Gotgatan — Rorsmansgatan
5	Sibbarp
6	Djupadals school
7	Mellanhedsgatan — Bellevuevägen
8	Technical Museum
9	Bagers plats
10	Centralstation
11	Grimsbygatan — Mejselgatan
12	Bultgatan
13	Kirsebergs school
14	Folkets Hus
15	Stadshuset
16	Carl-Gustafs väg — Förstadsgatan

Mölndal

Monthly average values for sulfur dioxide in pphm. Oct-Dec 1962.

stn.	okt	nov	dec
1	1,5	2,2	3,1
2	2,6	3,2	3,2
3	3,6 (1)	**6,3** (4)	4,6
4	4,0	4,1 (1)	3,9
5	2,8	4,5	**2,8**
6	3,4	**5,3**	3,5
7	4,5	4,3 (1)	**5,1**
8	4,3	3,8 (1)	3,5

Januari—december 1963.

stn.	jan	feb	mars	apr	maj	juni	juli	aug	sept	okt	nov	dec
1	**6,7** (6)	3,5	2,8	0,8	0,9	0,6	—	—	0,2	0,7	0,9	3,5
2	**8,8** (11)	3,9 (1)	3,4	2,2	2,3	0,5	—	—	0,3	1,2	1,6	4,8
3	**15,4** (20)	**9,1** (14)	**5,9** (5)	4,6 (2)	2,1	0,8	0,6	1,4	1,6	2,4	3,6	**7,5** (1)
4	**11,0** (11)	**5,3** (2)	4,1 (1)	2,3	1,8	0,8	—	—	1,3	2,2	2,9	**6,1** (2)
5	**10,1** (9)	—	4,7 (2)	2,5	1,9	0,7	—	—	0,6	1,1	2,2	**5,8**
6	**7,4** (5)	**5,0** (2)	4,4	2,8	2,4	1,2	—	—	0,9	1,4	3,1	4,6
7	**14,3** (19)	**6,0** (2)	4,3	3,1	3,1	1,6	—	—	2,8	4,4	**5,2**	**9,7**
8	**10,2** (6)	**5,1**	3,0	2,3	1,9	0,3	—	—	0,2	0,5	1,1	4,7

Januari—december 1964.

stn.	jan	feb	mars	apr	maj	juni	juli	aug	sept	okt	nov	dec
1	2,1	3,0	1,8	0,8	0,1	—	—	—	0,1	0,5	0,8	1,4
2	3,8 (1)	3,1 (1)	3,0	1,8	0,5	—	—	—	0,1	0,3	0,6	1,1
3	**6,4** (5)	**6,5** (2)	**8,0** (2)	2,3	0,8	0,1	0,5	0,3	0,9	2,3	2,9	4,5 (1)
4	4,7 (1)	4,0	4,3	2,1	1,4	—	—	—	0,7	1,6	2,2	3,0
5	2,9	3,4	4,3	1,9	0,7	—	—	—	0,3	1,2	1,8	3,0
6	3,7 (1)	3,5	4,3	2,1	—	—	—	—	1,5	3,2	2,4	2,9
7	**8,2** (6)	**6,4** (3)	3,1	3,7	2,3	—	—	—	1,0	2,4	2,7	3,6
8	3,4 (1)	3,3	2,4	1,5	0,6	—	—	—	0,2	1,1	—	1,8

Januari—september 1965.

stn.	jan	feb	mars	apr	maj	juni	juli	aug	sept	okt	nov	dec
1	1,4	2,5	2,5	2,5	0,3	—	—	—	0,2			
2	1,8	4,4	2,6	0,6	0,5	—	—	—	0,4			
3	4,7 (1)	**7,7** (8)	**5,1**	2,9	1,8	0,3	0,1	0,6	1,5			
4	2,6	4,9	3,6	1,7	1,2	—	—	—	1,3			
5	3,7	4,5 (1)	2,9	1,7	0,4	—	—	—	0,8			
6	**5,2** (2)	4,8 (1)	3,8	3,9	1,8	—	—	—	1,1			
7	3,0	**6,6** (4)	**5,1** (1)	2,0	1,7	—	—	—	**1,2**			
8	2,1	3,5	2,8	1,0	0,7	—	—	—	**0,5**			

Sampling sites in Mölndal

Station nr	Location
1	Abyvallen
2	Göteborgsvägen — Broslättsgatan
3	Folkets Hus
4	Verkstadsskolan
5	Lammevallsgatan — Frejagatan
6	Kvarnbygatan
7	Kronikerhemmet
8	Lekskolegatan

Skvide

Monthly average values for sulfur dioxide in pphm. May 1962-Apr 1963 with station 6 also reporting from Jun 63 to Apr 64.

stn	maj	juni	juli	aug	sept	okt	nov	dec	jan	febr	mars	april
6	2,9	2,6 (2)	2,1	1,5	3,3	4,0	4,9 (2)	**6,5** (4)	**7,3** (4)	**7,9** (7)	4,7	**7,6**
7	2,2	1,6	2,0 (1)	2,9	1,8	2,5	3,3	2,9	**5,3**	**5,7**	4,3	4,9
8	1,3	2,2 (1)	1,9 (1)	2,1	2,0	2,0	3,9	3,4	4,3	3,9	2,8	2,4
9	2,4	1,8	2,2 (1)	2,0	2,2	2,5	2,9 (1)	3,0	4,1	4,4	3,0	3,7
10	1,4	2,5	2,6 (1)	2,2	2,1	2,8	2,7	2,9	**5,3**	4,9	3,0	1,9
11	1,2	3,0 (2)	1,2	1,4	2,0	2,5	2,8	2,8 (1)	3,6	3,2	2,4	1,9
12							1,7	0,9	1,8	2,4	1,6	3,3
6 (1963—1964)		1,9 (1)	2,3	1,6	2,1	4,8 (2)	4,1	**6,2** (4)	**6,6** (5)	**6,3** (4)	3,5 (1)	3,8

Monthly average values for soot in $\mu g/m^3$.
1 May 62-30 Apr 63 and station 6 also reporting from 1 Jun 63- 30 Apr 64.

stn	maj	juni	juli	aug	sept	okt	nov	dec	jan	febr	mars	april
1		2	2	4	8	10	16	16 (2)		21 (2)	17	14
2	8	7	5	7	10	13	20 (1)	18 (3)	16 (3)	21 (1)	19	15
3	14	10	6	10	12	15	21	22 (3)	26 (5)	26 (2)	20	19
4	10	9	6	2	2	14	18	21 (2)	18 (2)	24 (1)	16	14
5	8	5	4	5	13	12	15	15	20 (1)	21	14	10
6	15	10	10	8	20	26 (3)	28 (2)	32 (5)	35 (7)	42 (7)	34 (5)	23 (1)
7	20	14	8	12	24	27 (1)	33 (2)	38 (6)	39 (7)	47 (9)	34 (5)	27 (1)
8	18	12	9	9	17	21	27 (1)	31 (4)	39 (6)	38 (4)	26 (1)	24
9	12	9	5	7	14	18	16	24 (2)	31 (5)	27 (3)	14	18
10	11	20	8	11	16	20 (2)	18	26 (4)	41 (9)	32 (5)	21 (1)	20
11	7	7	3	4	8	10	11	17 (1)	21 (3)	21 (1)	13	12
12						8	18	16	14 (2)	21 (1)	20	15
1963—1964												
6		32 (7)	16 (2)	43 (11)	41 (10)	45 (10)	**69** (15)	47 (8)	35 (5)	**53** (14)	49 (14)	46 (12)

Sampling sites in Skövde

Station nr	Location
1	Gudhemsgatan 22
2	Vasagatan 36
3	Vasagatan 21
4	Parkgatan 17 A
5	Gröna vägen 12
6	Hertig Johans gata 16
7	Kyrkogatan 27
8	Skolgatan 2
9	Viktoriagatan 8
10	Östergatan 9 A
11	Björkvägen 23 B

Solna

Monthly average values for sulfur dioxide in pphm. Jul 63-Apr 63.

stn	juli	aug	sept	okt	nov	dec	jan	febr	mars	apr
1	0,31	0,28	0,08	—	1,67	1,55	1,30	1,95	1,78	1,27
2	0,21	0,15	0,14	1,38	1,95	1,92	1,15	1,50	1,20	1,18

Sampling sites are in the center of Solna and vicinity.

Stockholm

Continuous measurements since Nov 1965 have established two-hour average values. Average monthly values have been calculated only as of December 1966. In 1966 and 1967 there were 20 or 21 daily measurements per month. For these reasons a large number of values in excess of daily averages must be brought into relationship with the daily averages.

1	dec 1966
1	10,1 (7)

Januari—december 1967

Stn	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	11,6 (10)	8,6 (4)	5,6 (4)	6,9 (1)	3,8 (1)	2,2	1,0	1,9	4,3 (2)	5,2 (6)	7,9 (7)	13,2 (18)
2	15,3 (11)	8,2 (5)	6,9 (3)	5,4	3,9	1,9	1,1	0,9	3,0	3,8	5,8 (2)	9,5 (11)

Stockholm

Januari—maj 1968

Stn	jan	febr	mars	april	maj
1	**15,8** (24)	**11,8** (13)	**6,5** (4)	4,3	3,3
2	**11,4** (15)	**7,2** (6)	4,7	3,6	2,5

Sampling sites

Station nr	Location
1	Klarabergsgatan 33
2	Torkel Knutssonsgatan 20

Täby

Average monthly values for sulfur dioxide in pphm. Mar-May 1968

Stn	mars	april	maj
1	3,8 (13 daily val.)	3,7	3,9 (17 daily val.)

Uddevalla

Monthly average values for sulfur dioxide in pphm. Jan-Dec 1965.

Stn	1965 jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	3,3	4,0	4,1	2,2	1,1	0,7	0,7	1,0	1,2	1,9	3,3 (1)	3,1 (1)
2	2,2	2,3	2,9	1,1	0,7	0,6	0,6	0,6	0,6	1,2	1,8	2,5
3	—	2,7	1,4	0,5	0,4	0,3	0,3	0,6	0,5	0,4	0,6	1,0
4	—	0,7	2,0	0,6	0,4	0,3	0,3	0,5	0,5	0,6	1,3	1,7
5	—	1,7	2,8	0,8	0,5	0,4	0,3	0,5	0,6	1,1	1,3	1,9
6	—	1,7	2,1	0,5	0,3	0,3	0,3	0,4	0,4	1,1	0,3	1,2
7	—	1,0	1,1	0,4	0,3	0,5	0,3	0,3	0,4	0,5	0,7	1,1
8	—	—	—	1,2	0,6	0,3	0,5	0,7	0,5	0,9	2,3	3,2 (1)

Januari—mars 1966

1996 Stn	jan	febr	mars
1	2,3	**6,4** (2)	3,1
2	2,1	3,2 (2)	1,2
3	1,2	1,5	0,5
4	1,4	1,7	1,0
5	1,1	4,1	2,1
6	0,7	—	0,5
7	—	—	0,7
8	2,1	1,9	1,3

Uddevalla

Monthly average values for soot in ug/m^3. Jan-Dec 1965.

Stn	1965 jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	23,2 (3)	40,5 (10)	**57,6** (19)	30,7 (5)	26,6 (3)	22,6 (1)	21,8 (1)	26,9 (2)	34,1 (5)	37,5 (8)	**59,5** (14)	**57,0** (13)
2	15,2	12,5	21,6 (4)	10,6	5,6	3,4	2,3	4,7	9,0	14,8 (1)	15,7 (2)	21,7 (2)
3		5,8	18,6 (3)	6,8	4,4	2,7	2,7	4,1	6,1	8,2	11,7	12,6
4		9,6	22,4 (2)	6,3	6,6	4,3	3,5	3,9	7,1	11,4	18,3	19,2
5		9,9	24,2 (4)	8,3	5,3	3,9	2,8	5,2	9,4	14,5	19,1 (3)	13,3
6		19,5	28,2 (6)	9,8	7,2	5,8	4,0	6,1	14,3	22,4 (4)	16,2	28,5 (4)
7		7,3	15,1 (2)	5,4	3,8	2,0	1,9	3,4	5,9	9,3	10,8	14,6
8				10,1	7,7	3,2	2,1	4,1	7,8	13,5 (1)	19,7 (3)	32,6 (5)

Uddevalla

Januari—mars 1966

1966 Stn	jan	febr	mars
1	29,8 (1)	71,4 (3)	29,5 (2)
2	14,4	24,0 (3)	6,6
3	10,4	14,4	3,7
4	20,3	18,1	7,3
5	7,8	15,7 (1)	7,6
6	8,6	—	7,9
7	—	—	8,0
8	12,5	19,9 (1)	6,9

Sampling sites in Uddevalla

Station nr	Location
1	Rådhuset
2	Västerskolan
3	Skogslyckan
4	Isbanan
5	Egersberg
6	Bäveån
7	Åsperöd
8	Söderskolan

Uppsala

Monthly average values for sulfur dioxide in pphm. Dec 1966-Jan 1968.

Station = Drottninggatan

1966 dec	1967 jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec	1968 jan
6,1 (3)	7,8 (5)	4,3	2,5	2,5	2,0	2,2	2,8	3,0	—	2,8	2,2	2,6	3,7

Västerås

Monthly average values for sulfur dioxide in pphm. Nov 65-Dec 66.

1965

stn	nov	dec
1	1,4	1,4
2	1,3	1,9
3	0,8	1,0
4	0,7	0,9
5	1,5	1,4
6	0,9	1,1
7	1,3	1,5

Sampling sites in Västerås

Station nr	Location
1	Fryxellska Skolan
2	Gustavsgatan
3	Johannisbergs flygplats
4	S:ta Gertruds skola
5	Zimmermanska skolan
6	Kristiansborgsskolan
7	Geijersgatan

1966

stn	jan	febr	mars	april	maj	juni	juli	aug	sept	okt	nov	dec
1	1,5	2,2	1,0	0,6	<0,5	<0,5	<0,5	<0,5	<0,5	1,0	0,8	1,7
2	1,7	1,7	1,3	0,5	<0,5	<0,5	<0,5	<0,5	<0,5	0,9	0,8	1,6
3	1,2	1,2	0,5	1,2	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	<0,5	1,3
4	0,9	1,8	0,7	0,5	<0,5	<0,5	<0,5	<0,5	<0,5	0,5	1,0	2,0
5	1,8	2,7	1,1	1,1	<0,5	<0,5	<0,5	<0,5	<0,5	0,7	1,0	1,8
6	1,2	1,6	0,8	0,7	<0,5	<0,5	<0,5	<0,5	<0,5	0,8	1,4	1,1
7	1,7	2,9	1,3	1,0	0,6	<0,5	<0,5	<0,5	<0,5	1,0	1,1	1,3

Appendix 4

REGULATIONS IN LOCAL PUBLIC HEALTH ORDINANCES FOR OIL-BURNING HEATING INSTALLATIONS IN THE CITY OF STOCKHOLM

#28 b

Oil-burning heating installations shall be arranged and installed, maintained and cared for such that sanitary inconveniences shall not occur as a result of emission of sulfur dioxide, soot, and ashes. To this effect, emissions of sulfur dioxide shall not exceed 20 grams per kg of oil, equivalent to a sulfur content of oil of 1.0%.

Temporary regulations to #28b

This notification takes effect October 1, 1968. For oil-burning heating installations in use before October 1, 1968 and those located outside the city sections of Broarna, Riddarholm, Norrmalm, Vasastad, Östermalm, Skeppsholm, Djurgården, Ladugårdsgärdet, Hjorthagen, Brunnsviken, Kungsholmen, Stadshagen, Marieberg, Fredhäll, Kristineberg, Södermalm, Lånholmen, as well as Hammarbyhamnen and Reimersholm, this regulation will be in effect as of October 1, 1969.

Appendix 5

PROPOSED REGULATIONS IN LOCAL PUBLIC HEALTH ORDINANCES FOR THE CITY OF GOTEBORG

Combustion installations shall be arranged and installed, as well as maintained and cared for such that no hygienic inconveniences will occur as a result of the emission of flue gases, soot, substances, and other combustion products.

To achieve this the following will be in effect:

1. General regulations for combustion installations:

Soot and substance emission for each boiler (oven, installation) shall not exceed the values given below:

Emission	Limits	Remarks
Soot particles according to the Bacharach scale	Maximum 4	Upon starting, load changes and sweeping while installation is operating, scale number 6 for a maximum of 15 minutes.
Total substance emission	Maximum 0.2 g/N m^3	Emissions are calculated as mean value for 30 minutes. Measurements will be made according to the BP-method, or a similar method.

Manual sweeping of shut-down boiler (boilers, installations) shall be performed ch that emission of substances into the atmosphere during the sweeping and subsequent startup will be avoided.

When sweeping while installation is in operation (blast, steam or air sweeping) emission values given above shall not be exceeded.

2. Special regulations for oil-burning heating installations. The emission of sulfur dioxide shall not exceed 20 grams per kg of oil, corresponding to a sulfur content in oil of 1.0%.

Particle emission for each boiler unit operating continuously shall not exceed the following values:

Emission	Limits	Remarks
Emission of unburned particles (soot)	Maximum 1.5 grams per kg of oil	The emission is calculated as mean value for 30 minutes and measured by the Shell or similar chemical scale.
Total particle emission	Maximum 2 grams per kg of oil	The emission is calculated as mean value for 30 minutes. The BP- or similar method will be employed.

Installations of oil-burning furnaces with a capacity less than 50 kg per hour (ca. 500 Mcal/h, or 580 kW) will be confined to use of No. 1 fuel oil. (For oil-burning installations set up after July 1, 1968, special instructions set up by the State Planning Agency will be in effect.

3. Temporary regulations. See the health regulations in Para. 00:1, which are effective as of October 1, 1969.

See in Para. 00:2 which will be effective:

in Zone 1 (city sections such as Vallgrav, Nordstad, Gullbergsvass, Stamp, Heden, Lorensberg, Johanneberg, Krokslätt, Landala, Pustervik, Masthugget, Stigberget, Olivedal,

Haga, Kommendantsängen and Annedal) on October 1, 1969;

in Zone 2* (city sectior Majornas 1:a rote, Majornas 2:a rote, Majornas 3:e rote, Majornas 4:e rote, Färjestad, Sannegård, Lindholm, Lundbyvass, Brämergård, Kvillebäck, Tingstadvass, Gamlestad, Kviberg, Bagaregård, Olskrok, Gårda, Källtorp, Sävenäs and Utby) on October 1, 1971;

in Zone 3 (other city sections) on October 1, 1974.

* Para. 00:2 probably will be effective for Zone 2 before October 1, 1971 (Remark by the National Environmental Protection Service).